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BRAZING — STEEL, COPPER, ALUMINUM, NICKEL, AND MAGNESIUM ALLOYS, SPECIFICATION FOR

ENGINEERING DEVELOPMENT DIRECTORATE

National Aeronautics and
Space Administration

John F. Kennedy Space Center

KSC FORM 16-12 (REV 7/92)

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BRAZING — STEEL, COPPER, ALUMINUM, NICKEL, AND MAGNESIUM ALLOYS, SPECIFICATION FOR

Approved:

Walter T. Murphy
Director of Engineering Development

JOHN F. KENNEDY SPACE CENTER, NASA

P1/WP60/SPEC-Z05 A

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ABBREVIATIONS AND ACRONYMS

Ag	silver
Al	aluminum
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
Au	gold
AWS	American Welding Society
B	boron
Be	beryllium
C	carbon
°C	degree Celsius
Cb	columbium (niobium)
Cd	cadmium
Cr	chromium
Cu	copper
°F	degree Fahrenheit
Fe	iron
KSC	John F. Kennedy Space Center
Li	lithium
Liq.	liquidus
Max.	maximum
Mg	magnesium
MIL	military
min.	minimum
mm	millimeter
Mn	manganese
Mo	molybdenum
NASA	National Aeronautics and Space Administration
Ni	nickel
P	phosphorus
Pb	lead
rem.	remainder
Si	silicon
Sn	tin
Sol.	solidus
SPEC	specification
STD	standard
Ta	tantalum
Ti	titanium
V	vanadium

ABBREVIATIONS AND ACRONYMS (cont)

W	wolfram (tungsten)
Zn	zinc
Zr	zirconium

BRAZING — STEEL, COPPER, ALUMINUM, NICKEL, AND MAGNESIUM ALLOYS, SPECIFICATION FOR

1. SCOPE

1.1 Scope. - This specification covers brazing, inspection of brazed joints, and qualifying of brazers, brazing operators, and brazing procedures.

1.2 Criticality. - Brazing performed to this specification shall be classified by criticality as follows:

a. Class A - Critical Application. A brazed joint is critical where a failure of any portion would cause loss of system, loss of a major component, loss of control, unintentional release of critical stores, or hazard to personnel. (Except as defined otherwise on the engineering drawings or in the procurement documents, all brazing shall be considered Class A.)

b. Class B - Semicritical Application. A brazed joint is semicritical when the failure would reduce overall efficiency of the system but loss of system or hazard to personnel would not be experienced.

c. Class C - Noncritical Application. A brazed joint is noncritical where failure would not affect system efficiency or create hazard to personnel.

1.3 Processes. - This specification covers requirements applicable to the following brazing processes:

a. Torch brazing

b. Furnace brazing

c. Induction brazing (except aerospace tubing fittings as defined in KSC-SPEC-Z-0006)

d. Resistance brazing

e. Dip brazing

f. Infrared brazing

2. APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein. When this document is used for procurement, including solicitations, or is added to an existing contract, the specific revision levels, amendments, and approval dates of said documents shall be specified in an attachment to the Solicitation/Statement of Work/Contract.

2.1 Governmental.

2.1.1 Specifications.

Kennedy Space Center (KSC), NASA

KSC-SPEC-Z-0006	Brazing, Induction, Aerospace Tubing Fittings, Specification for

2.1.2 Standards.

Military

MIL-STD-453	Inspection, Radiographic
MIL-STD-6866	Inspection, Penetrant Method of

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the Contracting Officer.)

2.2 Non-Governmental.

American National Standards Institute (ANSI)/American Welding Society (AWS)

ANSI/AWS A5.8	Specification for Filler Metals for Brazing and Braze Welding

(Application for copies should be addressed to the American Welding Society, Inc., 2501 N.W. 7th Street, Miami, FL 33135.)

American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code

Section IX — Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators

(Application for copies should be addressed to the American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017.)

3. REQUIREMENTS

3.1 Material.

3.1.1 Base Metals. - Base metals that may be brazed in accordance with this specification are carbon and low-alloy steels, stainless steels, copper, copper alloys, aluminum, aluminum alloys, nickel alloys, magnesium, and magnesium alloys. Base metal-filler metal combinations shall be as shown in table 1.

3.1.2 Brazing Filler Metals. - Recommended brazing filler metals to be used in accordance with the requirements of this specification are shown in table 2.

3.1.3 Fluxes. - Fluxes shall be used as required to promote free flow of filler metals into the joint interstice. Fluxes shall dissolve any oxides in the joint area and shall prevent additional oxidation of the base metals and filler metals during heating. Fluxes may be applied as powder, paste, vapor gas, or coating on filler metals.

3.2 Brazing Process. - The brazing process to be used (see 1.3) shall be in accordance with the qualified brazing procedure specification (see 4.3).

3.2.1 Joint Design. - The brazed joint design shall be in accordance with the engineering drawing and the qualified brazing procedure specification (see 4.3).

3.2.2 Alignment of Parts. - Parts to be joined shall be securely held in relative positions by jigs, clamps, or supports. One part shall have sufficient freedom of movement to prevent cooling restraint stresses. Spot welding, in areas not subject to high stresses in service, may be used if permitted by the engineering drawings.

Table 1. Base Metal-Filler Metal Combinations

	Al and Al Alloys	Mg and Mg Alloys	Cu and Cu Alloys	Carbon and Low Alloy Steels
Al and Al Alloys	BAlSi	X	X	BAlSi
Mg and Mg Alloys	X	BMg	X	X
Cu and Cu Alloys	X	X	BAg, BAu, BCuP, RBCuZn	BAg, BAu, RBCuZn
Carbon and Low Alloy Steels	BAlSi	X	BAg, BAu, RBCuZn	BAg, BAu, BCu, RBCuZn, BNi
Cast Iron	X	X	BAg, BAu, RBCuZn	BAg, RBCuZn
Stainless Steel	BAlSi	X	BAg, BAu	BAg, BAu, BCu, BNi
Ni and Ni Alloys	X	X	BA, BAu, RBCuZn	BAg, BAu, BCu, RBCuZn, BNi
Ti and Ti Alloys	BAlSi	X	BAg	BAg
Be, Zr, V and Alloys * (Reactive Metals)	BAlSi (Be)	X	BAg	BAg, BNi
W, Mo, Ta, Cb and Alloys (Refractory Metals)	X	X	BAg	BAg, BCu, BNi
Tools Steels	X	X	BAg, BAu, RBCuZn, BNi	BAg, BAu, BCu, RBCuZN, BNi
X - Not recommended				

* CAUTION: Contains beryllium which may give off toxic fumes. Adequate ventillation for safety of personnel must be provided.

Table 1. Base Metal-Filler Metal Combinations (cont)

	Cast Iron	Stainless Steels	Ni and Ni Alloys	Tool Steels
Al and Al Alloys	X	BAlSi	X	X
Mg and Mg Alloys	X	X	X	X
Cu and Cu Alloys	BAg, BAu, RBCuZn	BAg, BAu	BAg, BAu, RBCuZn	BAg, BAu, RBCuZn, BNi
Carbon and Low Alloy Steels	BAg, RBCuZn	BAG, BAu, BCu, BNi	BAg, BAu, BCu, RBCuZn, BNi	BAg, BAu, BCu, RBCuZn, BNi
Cast Iron	BAg, RBCuZn, BNi	BAg, BAu, BCu, BNi	BAg, BCu, RBCuZn	BAg, BAu, BNi, RBCuZn
Stainless Steel	BAg, BAu, BCu, BNi	BAg, BAu, BCu, BNi	BAg, BAu, BCu, BNi	BAg, BAu, BCu, BNi
Ni and Ni Alloys	BAg, BCu, RBCuZn	BAg, BAu, BCu, BNi	BAg, BAu, BCu, BNi	BAg, BAu, BCu, RBCuZn, BNi
Ti and Ti Alloys	BAg	BAg	BAg	BAg
Be, Zr, V and Alloys * (Reactive Metals)	BAg, BNi	BAg, BNi	BAg, BNi	BAg, BNi
W, Mo, Ta, Cb and Alloys (Refractory Metals)	BAg, BCu, BNi	BAg, BCu, BNi	BAg, BCu, BNi	BAg, BCu, BNi
Tools Steels	BAg, BAu, RBCuZn, BNi	BAg, BAu, BCu, BNi	BAg, BAu, BCu, RBCuZn, BNi	BAg, BAu, BCu, RBCuZN, BNi
X - Not recommended				

* CAUTION: Contains beryllium which may give off toxic fumes. Adequate ventillation for safety of personnel must be provided.

Table 2. Brazing Filler Metals

Alloy	Composition (by percent)									Other		Temperature (°F)			Temperature (°C)		
Copper Phosphorus	P	Ag	Cu							Each	Total	Sol.	Liq.	Brazing Range	Sol.	Liq.	Brazing Range
BCu P-1	4.75-5 25		rem.								0.15	1310	1690	1450-1700	710 0	921.1	787.8-926.7
BCu P-2	7.00-7 50		rem.								0 15	1310	1460	1350-1550	710 0	793.3	732.2-843.3
BCu P-3	5.75-6.25	4 75-5 25	rem.								0.15	1190	1485	1300-1500	643.3	807.2	704.4-815.6
BCu P-4	7.00-7 50	5.75-6.25	rem.								0 15	1190	1335	1300-1450	643 3	723.9	704.4-787.8
BCu P-5	4 75-5.25	14 5-15 5	rem.								0.15	1190	1475	1300-1500	643.3	801.7	704.4-815.6
Silver	Ag	Cu	Zn	Cd	Ni	Sn	Li	P									
BAg-1	44-46	14-16	14-18	23-25							0.15	1125	1145	1145-1400	607.2	618 3	618.3-760 0
BAg-1a	49-51	14 5-16.5	14 5-18.5	17-19							0.15	1160	1175	1175-1400	626.7	635.0	635.0-760.0
BAg-2	34-36	25-27	19-23	17-19							0.15	1125	1295	1295-1550	607.2	701 7	701.7-843.3
BAg-3	49-51	14.5-16.5	13.5-17.5	15-17	2.5-3 5						0 15	1170	1270	1270-1500	632.2	687.8	687.8-815.6
BAg-4	39-41	29-31	26-30		1 5-2 5						0.15	1240	1435	1435-1650	671.1	779.4	779.4-898.9
BAg-5	44-46	29-31	23-27								0.15	1250	1370	1370-1550	676.7	743.3	743.3-843.3
BAg-6	49-51	33-35	14-18								0.15	1270	1425	1425-1600	687.8	773.9	773.9-871.1
BAg-7	55-57	21-23	15-19			4.5-5.5					0.15	1145	1205	1205-1400	618.3	651.7	651.7-760.0
BAg-8	71-73	rem.									0.15	1435	1435	1435-1650	779 4	779.4	779.4-898 9
BAg-8a	71-7.	rem					0.15-0.30				0.15	1410	1410	1410-1600	765 6	765.6	765.6-871 1
BAg-13	53-55	rem.	4.0-6.0		0 5-1.5						0.15	1325	1575	1575-1775	718.3	857.2	857 2-968 3
BAg-18	59-61	rem				9 5-10.5		0 025			0.15	1115	1325	1325-1550	601 7	718.3	718.3-843 3
BAg-19	92-93	rem					0 15-0 30				0.15	1435	1635	1610-1800	779 4	890.6	876 7-982 2
Copper and Copper Zinc	Cu	Zn	Sn	Ni	P	Pb	Al	Si									
BCu-1	99 9 min.				0.075	0.02	0.01				0.10	1980	1980	2000-2100	1082.2	1082.2	1093.3-1148.9
BCu-1a	99.0 min.										0.30	1980	1980	2000-2100	1082.2	1082 2	1093 3-1148.9
BCu-2	86.5 min.										0.50	1980	1980	2000-2100	1082.2	1082 2	1093.3-1148 9
RBCu-Zn-A	57-61	rem	0 25-1 0			0 05	0 01				0.50	1630	1650	1670-1750	887.8	898 9	910.0-954 4
RBCu-Zn-D	46-50	rem.		9.0-11.0	0 25	0.50	0.01	0.04-0.25			0 50	1690	1715	1720-1800	921.1	935.0	937.8-982.2
Aluminum-Silicon	Si	Cu	Fe	Zn	Mg	Mn	Cr	Ti	Al								
BAlSi-2	6.8-8.2	0.25	0 8	0 20		0 10			rem	0.05	0.15	1070	1135	1110-1150	576.7	612.8	598.9-621.1
BAlSi-3	9 3-10.7	3.3-4.7	0.8	0 20	0.15	0.15	0.15		rem.	0.05	0 15	970	1085	1060-1120	521.1	585.0	571.1-604 4
BAlSi-4	11.0-13.0	0.30	0.8	0.20	0.10	0.15			rem.	0.05	0 15	1070	1080	1060-1120	576.7	582.2	571.1-604.4
BAlSi-5	9.0-11.0	0.30	0.8	0.10	0.05	0.05		0 20	rem.	0.05	0.15	1070	1095	1090-1120	576.7	590.6	587 8-604 4

Table 2. Brazing Filler Metals (cont)

Alloy	Composition (by percent)											Temperature (°F)			Temperature (°C)		
										Other							
Precious Metals	Au	Cu	Ni							Each	Total	Sol.	Liq.	Brazing Range	Sol.	Liq.	Brazing Range
B-Au-1	37 0 +1 -0	rem									0.15	1815	1860	1860-2000	990.6	1015.6	1015 6-1093.3
B-Au-2	79.5 +1 -0	rem									0 15	1635	1635	1635-1850	890 6	890.6	890.6-1010.0
B-Au-3	34.5 +1 -0 +1	rem	2 5-3.5								0..15	1785	1885	1885-1995	973.9	1029.4	1029.4-1090 6
B-Au-4	81.5-0		rem.								0.15	1740	1740	1740-1840	948.9	948 9	948.9-1004.4
Nickel	Ni	Cr	B		Si		Fe	C Max	P								
B-Ni-1	rem.	13.0-15.0	2.75-4.00		3.0-5.0		4 0-5.0	0.6-0.9			0 50	1790	1900	1950-2200	976.7	1037.8	1065.6-1204.4
B-Ni-2	rem.	6 0-8 0	2.75-3 5		4.0-5.0		2 0-4.0	0.15			0 50	1780	1830	1850-2150	971.1	998.9	1010 0-1176.7
B-Ni-3	rem.		2 75-3.5		4.0-5.0		1.5	0.06			0 50	1800	1900	1850-2150	982.2	1037.8	1010.0-1176.7
B-Ni-4	rem.		1.0-2.2		3.0-4 0		1.5	0.06			0.50	1800	1950	1850-2150	982.2	1065.6	1010.0-1176 7
B-Ni-5	rem.	18.0-20.0			9.75-10 5			0.15			0.50	1975	2075	2100-2200	1079.4	1135 0	1148.9-1204 4
B-Ni-6	rem							0.15	10.0-12.0		0.50	1610	1610	1700-1875	876.7	876 7	926.7-1023.9
B-Ni-7	rem.	11.0-15.0							9.0-11.0		0.50	1630	1630	1700-1900	887.8	887.8	926.7-1037.8
Magnesium	Al	Mn	Zn	Si	Cu	Ni	Fe	Be	Mg								
* BMg-1	8.3-9.7	0.15 min.	1.7-2.3	0.05	0.05	0.005	0.005	0.0002-0.0008	rem.		0.30	830	1110	1120-1160	443.3	598.9	604.4-626.7
BMg-2	11.0-13.0		4.5-5.5						rem.		0 30	770	1050	1080-1130	410.0	565.6	582 2-610.0
* BMg-2a	11.0-13.0		4.5-5 5					0.0002-0.0008	rem		0.30	770	1050	1080-1130	410.0	565.6	582 2-610.0

* Caution: Contains 0.0005 percent beryllium which may give off toxic fumes. Adequate ventilation for safety of personnel must be provided.

NOTE: Table 2 values are from ANSI/AWS A5.8-62T.

3.2.3 Fit. - The clearance between mating surfaces shall be in accordance with the qualified brazing procedure. Unless otherwise specified, recommended clearances for various filler metals shall be as shown in table 3.

3.2.4 Cleaning. - Before brazing, the joint mating surfaces and adjacent areas shall be thoroughly cleaned to remove oxides, grease, oil, and other foreign matter. Cleaning methods shall be as specified in the qualified brazing procedure specification.

3.2.5 Flux. - Flux, as specified in the qualified brazing procedure specification, shall be applied to the joint mating surfaces prior to the introduction of the filler metal.

3.2.6 Atmosphere.

3.2.6.1 Furnace Brazing. - When furnace brazing is used, the furnace atmosphere shall be such as to prevent excessive decarburizing of carbon and low-alloy steels, and avoid carburization of stainless steels. Decarburization in excess of 0.08 mm (0.003 inch) total shall be considered excessive.

3.2.6.2 Induction Brazing. - When high-frequency induction brazing is used, the inert-gas shielding, internal, external, or both, shall provide an atmosphere such as to prevent oxidation. The qualified brazing procedure specification shall specify the gas, method of application, and flow rate.

3.2.7 Introduction of Filler Metal. - Except as specified on the engineering drawings or in the qualified brazing procedure specification (see 4.3), the filler metal shall be introduced into the joint interstice immediately after the base metals have reached brazing temperature. (See table 2.) Where furnace brazing is used, the filler metal shall be assembled with the joint before being placed in the furnace. Filler metal shall be so located that capillary attraction will draw it into the joint interstice immediately upon becoming molten. Heating time and temperature shall be kept to a minimum or as necessary to prevent joint embrittlement, base metal erosion, or other undesirable metallurgical reactions.

3.2.7.1 Joint Position. - The joint shall be positioned to permit the filler metal to flow into the joint assisted by gravitational attraction as well as capillarity. If positioning for gravitational flow is impractical, the brazing contractor shall produce specimens showing good filler metal joint penetration by capillary attraction for the approval of the NASA Quality Representative.

Table 3. Recommended Joint Clearances
(at Brazing Temperatures)

Filler Metal (AWS-ASTM Classification)	Joint Clearances	
	Millimeters (mm)	Inches
BAlSi Group	0.15 - 0.25 *	0.006 - 0.010 *
	0.25 - 0.64 *	0.010 - 0.025 *
BAg Group	0.05 - 0.13	0.002 - 0.005
BAu Group	0.05 - 0.13	0.002 - 0.005
BCuAu Group	0.05 - 0.13	0.002 - 0.005
BCu Group	0.00 - 0.05 **	0.000 - 0.002 **
BCuZn Group	0.05 - 0.13	0.002 - 0.005
BMg Group	0.10 - 0.25	0.004 - 0.010
BNi Group	0.05 - 0.13	0.002 - 0.005
BCuP Group	0.03 - 0.13	0.001 - 0.005

* For lap length less than 6.4 mm (0.25 inch)
** Press fit of 0.03 per 25.4 mm (0.001 per inch) diameter for maximum strength

3.2.7.2 Limits of Filler Metal. - Except where preplaced filler metal is utilized, filler metal shall be introduced into the joint until it may be observed filling the interstice at a location opposite to the point of introduction. Care shall be taken to prevent filler metal running over into areas adjacent to the joint. Masking shall be used when specified on the engineering drawings or in the qualified brazing procedure specification (see 4.3).

3.2.7.3 Penetration. - Filler metal shall completely penetrate the joint interstice.

3.2.8 Cooling. - After brazing, and prior to handling, assembled joints shall be gradually cooled to room temperature to permit solidification of the filler metal wherein the joint will not crack or scale, and will not be subjected to internal stress. Where heat treatment is performed in conjunction with brazing, cooling procedures may be modified as required.

3.2.9 Flux Removal. - Flux shall be removed from the joint area immediately after cooling. The joint may be immersed in hot water {60 degrees Celsius (°C) [140 degrees Fahrenheit (°F)] minimum} until all traces of flux are removed. A suitable solvent that will not react with the joint metals may be used rather than hot water. When requested by the NASA Quality Representative, a suitable test shall be performed to determine complete removal of flux.

3.3 Heat Treatment. - Heat treatment following the brazing operation, when required, shall be limited to temperatures below the solidification temperature of the filler metal. Stainless steels brazed with silver alloys shall not be heated above 315 °C (600 °F).

3.4 Passivation of Stainless Steel Joints. - Stainless steel joints brazed with silver alloys shall not be subjected to nitric acid passivation.

3.5 Equipment. - Furnaces, torches, and induction and resistance heating equipment shall be maintained in good condition to insure proper heating to the required brazing temperatures. Equipment shall be operated within the operating ranges recommended by the equipment manufacturer.

3.6 Workmanship. - Brazed joints shall be free from visible flaws, such as incomplete filler metal penetration, voids, erosion, excessive filler metal buildup, or runover into areas adjacent to the joint. The joint area shall be free from residual flux deposits and shall show no signs of corrosion or undesirable metallurgical reaction.

3.7 Qualification.

3.7.1 Brazing Procedure Specification Certification. - Prior to starting production brazing under this specification, a brazing procedure specification shall be established and certified to demonstrate that brazed joints having suitable mechanical properties and soundness can be made by this procedure. Certification by the brazing contractor, subject to NASA approval, shall be as described in 4.3.

3.7.2 Performance Qualification. - Prior to performing brazing under this specification, brazers and brazing operators shall be certified by the brazing contractor, subject to NASA approval, as specified in 4.4.

3.7.3 Exceptions. - Workmanship samples shall be the only qualification requirement for Class C brazing and will be subjected to visual examination only.

4. QUALITY ASSURANCE PROVISIONS

4.1 Inspection Requirements. - The brazing contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the brazing contractor may utilize his own or any other inspection facilities and services acceptable to KSC. Inspection and test records shall be kept complete and, upon request, made available to the procuring activity or its designated representative. The procuring activity, or its designated representative, reserves the right to perform any and all of the inspections set forth in this specification to assure that the end item conforms to the prescribed requirements.

4.2 Inspection.

4.2.1 Visual Inspection. - Joint setups shall be visually inspected before and after brazing. The joint setups shall conform to the requirements of the qualified brazing procedure. External fillet size and contour shall not be causes for rejection unless so stated in the engineering drawings, or unless excessive material would interfere with mating parts. Penetration, as required by the joint design and engineering drawings, shall be verified. Incomplete penetration shall be cause for rejection.

4.2.2 Radiographic Inspection. - Radiographic inspection shall be performed on all Class A joints and on Class B joints when required by the engineering drawings or procurement documents. Radiographic inspection shall be performed in accordance with MIL-STD-453. Radiographic acceptance criteria shall include the following:

a. Class A Acceptance Criteria. - Voids and inclusion shall not comprise an aggregate area exceeding 15 percent of the joint area and, for pressure tight joints, shall not reduce the leakage barrier width by more than 15 percent. No voids shall be open to the pressurized surface.

b. Class B Acceptance Criteria. - Voids and inclusion shall not comprise an aggregate area exceeding 25 percent of the joint area and, for pressure tight joints, shall not reduce the leakage barrier width by more than 25 percent. No voids shall be open to the pressurized surface.

c. Manual Torch Silver Brazing. - For manual torch brazing only, for Class A and Class B brazing, voids and inclusions shall not comprise an aggregate area exceeding 30 percent of the joint area. Additionally, for

joints required to be pressure tight, voids or inclusions shall not reduce the leakage barrier width by more than 50 percent for joints in copper alloys, or more than 25 percent for all other alloys. In addition, no defect shall extend continuously from one surface of the joint to the other surface, irrespective of the direction of the defect.

4.2.3 Penetrant Inspection. - When required by the engineering drawings or the procurement documents, penetrant examination shall be performed in accordance with MIL-STD-6866. Acceptance criteria for penetrant inspection shall be as specified by the engineering drawings or the procurement documents which specify the test requirements.

4.2.4 Other Inspections. - The NASA Quality Representative may, at his discretion, require other inspections to determine the soundness of brazed joints.

4.3 Brazing Procedure Specification Certification. - Each brazing procedure shall be documented by the brazing contractor in the form of a procedure specification that shall meet the requirements of this specification and shall be approved by the NASA Quality Representative. Certification of the procedure specification shall be as required by the ASME Boiler and Pressure Vessel Code, Section IX.

4.3.1 Brazing Procedure Specification. - The brazing procedure specification shall include the following:

a. Base metal (material and thickness)

b. Sketch of joint

c. Filler metal

d. Precleaning and prebraze surface treatment

e. Fluxes, when required

f. Brazing process

g. Brazing position

h. Other requirements including torch tip size, fuel gas and pressure, current, and frequency

i. Furnace atmosphere or inert gas purge and shielding data, when required

j. Preheat temperature

k. Brazing temperature

l. Method of placing filler metal

m. Tolerances or clearance of joints

n. Heat treatment

o. Postbraze cleaning

p. Inspection requirements

q. Remarks

r. Acceptance criteria for applicable test samples

4.3.2 Records. - All certified brazing procedure specifications shall be recorded in detail and shall be adhered to during subsequent construction, except where a change is specifically authorized by the procuring activity.

4.3.3 Gas or Liquid Tightness. - When gas or liquid tightness is required of the brazed joints, a hydrostatic test of one and one-half times the maximum service pressure shall be conducted on specimens of types of joints subject to gas or liquid tightness in service. Leak testing with helium, using a mass spectrometer, shall be conducted on specimens for Class A applications when required by the procurement documents or the engineering drawings.

4.4 Performance Qualification.

Brazing shall be performed only by brazers or brazing operators who have been qualified in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section IX.

5. PREPARATION FOR DELIVERY

When required, preparation for delivery shall be as specified in the procurement documents.

6. NOTES

6.1 Intended Use. - This specification covers brazing, inspection of brazed joints, and qualification of brazing procedures, brazers, and brazing operators for general brazing in Classes A, B, and C.

6.2 Data Required on Drawings or Procurement Documents.

a. Title, number, and date of this specification

b. Postbrazing heat treatment

c. Radiographic inspection requirements for Class B joints

d. Penetrant inspection requirements and acceptance criteria

e. Helium leak test requirements

f. Delivery preparation requirements, when required

g. Spot welding permission, if applicable

h. Limitations of filler metal introduction, if applicable

i. Deviations to specified filler metal clearances, if applicable

j. Joint design

k. Filler metal runover masking, when required

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Preparing Activity:

John F. Kennedy Space Center
Mechanical GSE Division
Engineering Development Directorate

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
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I RECOMMEND A CHANGE:	1 DOCUMENT NUMBER KSC-SPEC-Z-0005A	2 DOCUMENT DATE January 25, 1995

3. DOCUMENT TITLE
Brazing - Steel, Copper, Aluminum, Nickel, and Magnesium Alloys, Specification for

4 NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible Attach extra sheets as needed)*

5 REASON FOR RECOMMENDATION

6. SUBMITTER

a NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)*	7 DATE SUBMITTED

8. PREPARING ACTIVITY

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